SOIL SURVEY OF THE CANDO AREA, NORTH DAKOTA.

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LOCATION AND BOUNDARIES OF THE AREA.

Towner County is located in the northeastern quarter of the State, and is bounded on the north by the Canadian line. The greatest dimension of the county is from north to south, measuring 43½ miles, or a little more than seven tiers of townships, while its width from east to west is 24 miles, covering four townships. The area surveyed comprises the two southern tiers of townships and has an extent of

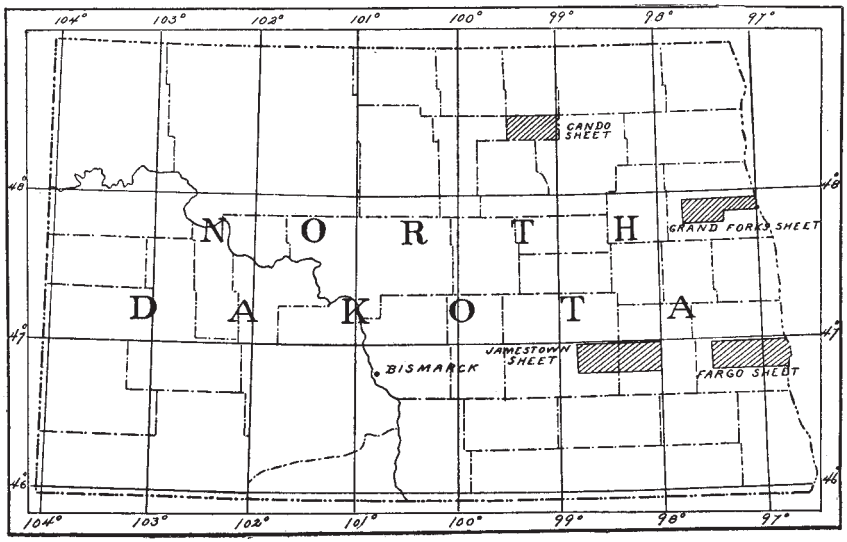

FIG. 39.—Sketch map showing location of the Cando area, North Dakota.

288 square miles, being 24 miles east and west by 12 miles north and south.

The main line of the Great Northern Railway crosses the State about 8 miles south of the county, and from Churchs Ferry a branch line extends in a northerly direction through the center of the area surveyed to the town of St. John, near the Canadian line, in Rolette County. Cando and Maza are the only shipping points in the area. Cando is a town of approximately 2,000 population, contains a number of substantial business houses engaged in handling the various supplies and products of the region, and is the site of large elevators

belonging to six different companies. Maza is a small village, being important chiefly as a grain-shipping center.

In the prosecution of the field work of the survey the Bureau had the cooperation of the State agricultural and economic geological survey, to the extent of furnishing two men and paying their expenses for a period of nearly a month and a half.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The area, like all of the surrounding region, is a comparatively new one agriculturally. It was first opened for settlement in 1883, and under the homestead and other similar Federal enactments, such as the tree-claim and preemption acts, all of the land has been taken up. No land was sold by the Government or granted to transportation companies. Upon the organization of the State in 1889 sections 16 and 36 of each township were given to the State for the purpose of creating a school fund from the moneys derived from the sale of such land, which is disposed of at public auction at a price not less than $10 an acre. Within 8 or 10 miles of Cando and Maza all the land had been taken up under the above provisions at least fifteen years ago, and in the area as a whole no land has been open for homesteading for five or six years. A little more than half the allotted school land remains in the possession of the State, and is the only "public land" available.

During the first six years settlement was rapid and most of the land was filed upon, the title being "proved" to a considerable part; but in the three years beginning with 1888 the crops were almost a complete failure because of weather conditions, and the loss fell so heavily on a large number of settlers that a great many of them were forced to abandon their land, which either reverted to the Government or went to persons holding it as security for loans. Indeed, it is said that at one time following the third failure, in 1890, the exodus was so great that it looked as if the region would be almost depopulated. Under these conditions a few of those who remained and were able to do so acquired much of this abandoned land by purchase at a very low figure. Quarter sections of land sold for $200 and $300, or even less, because, first, there was plenty of land in the vicinity to be acquired by simple residence; and, second, because most of the persons who had lent money on the land were willing, in the face of the financial conditions then prevailing, to accept whatever could be realized from an immediate sale. Large areas of land that now form some of the largest farms were acquired in this manner.

It is said to be a peculiarity of this region that about every third or fourth year since settlement began a large crop has been obtained, while in the intervening years crops have been either only moderate

or an actual failure. The year 1891 gave an immense crop, helping those still remaining in the region to retrieve their previous losses, and since that date there has been no repetition of the almost absolute failures of earlier years. In the following prosperous years active settlement was renewed and has continued to this time. Since the early nineties the price of land has been steadily advancing, this being especially true since 1898. Prices now range from $10 up to $35 an acre, depending on the character and condition of the soil and the location of the land with reference to the two towns and the railroad.

The population of the area has been drawn from many States and also from foreign countries. Men from New England and Illinois have settled here, and there are many of Norwegian parentage. Some of the latter, however, are Americans by birth and have come from Wisconsin and Minnesota.

From the very first spring wheat has been the staple money crop, to which all others are subsidiary. Barley, oats, and flax were early introduced to assist in getting the native prairie in good condition for growing wheat, the first two furnishing feed for horses and other stock; but in 1898 the relative prices of wheat and flax were such that on many farms flax was given the preference, and continued to increase in favor until about 1901 or 1902. Since that time the fluctuation in the price of both grains has restored the prestige of wheat, though flax is still grown in considerable quantities as one step in the rotation of crops. Flax and barley have long been considered very satisfactory as the first crop on new land, following which wheat succeeds better than if planted on virgin soil. The flax has always been grown for seed only. Within the past few years macaroni wheat has been introduced into the area and is increasing in favor among the farmers, several hundred acres of it being grown at present. The grain emmer, known here under the name of "spelt," has also been introduced. Both of these grains have been introduced at the instance of the Bureau of Plant Industry.

In considering the agricultural development of the region, the advent of the railroad in 1888 must be regarded as a highly important factor.

The changes in the methods practiced have been chiefly those that accompany the transition from the pioneer condition to the more intelligent system of the progressive, well-to-do farmer, who keeps pace with the improvements along agricultural lines. One change that may be noted in this connection, however, is the different treatment now given to new land, which was at first plowed shallow and the following spring "backset," or replowed after the sod had partially rotted. The land so managed was prepared and planted the

same season. Later the "backsetting" was omitted, and a practice now in vogue is to plow and prepare new land in the spring and seed it to a crop like flax. The success of this latter method is more dependent than the other on the moisture conditions of the current year, the yields being larger in wet seasons.

Some inquiry was made to determine whether there had been any appreciable reduction in crop yields on the lands longest in cultivation. The replies were varied, indicating that if there has been any decrease in yield it is so small as to be scarcely noticeable.

CLIMATE.

This area, with an average precipitation of nearly 20 inches, belongs to the semiarid division of the country, but there are certain modifying factors which almost place it in the humid division. An examination of the appended table, compiled from Weather Bureau records, will show that about 75 per cent of the rainfall occurs in the warmer months, from April to October, inclusive. These figures are normals for a series of years, and there are wide fluctuations from year to year, unusually dry seasons alternating with seasons in which the rainfall is sufficient to class the region with the humid country farther east. On the whole, the problem of a sufficient moisture supply is the most important one in the region, and the one that most largely determines the crop returns under the methods practiced. In the season of 1904, however, an excess, and not a deficiency, of rain caused much injury.

Frosts always occur early in September, and between the 1st and the 15th of November permanent low temperatures begin to prevail, the ground freezing and remaining so until the following spring. The humidity in winter is low, and consequently the low temperatures are not so severe on animal life as the figures would seem to indicate. Snow generally covers the ground to a depth of several feet throughout the winter, but the total amount of water that falls in this form, as shown by the tables, is only a fraction of an inch during each of the coldest four months. The ground freezes to a depth of from 5 to 8 feet.

About the 1st of April the soil begins to thaw, and usually from the 10th to the 20th of the month plowing and cultivation are possible, even though the soil be frozen below. By the 1st of May, or even earlier in some years, the surface soil is warm enough to germinate seed.

In this region a given amount of water is more effective in causing crop growth than in warmer sections, because the surface evaporation is less. As is indicated by the temperature of the ground water near the surface in wells and other places, the lower subsoil never

becomes very warm. All processes of oxidation and decomposition are correspondingly slow, and this fact, coupled with the additional one that the seasons are comparatively short, probably explains why all the soils are so rich in humus or partly decomposed organic remains. There is a comparatively small amount of leaching.

In winter the temperature sometimes falls to 40° below zero, and the general conditions are very severe on animal life. In summer hailstorms sometimes do great damage to crops if they happen to be in a nearly ripe condition. These storms, however, are never of general occurrence, and usually cover narrow strips from a fraction of a mile to several miles in width.

There is a free and unobstructed movement of the winds, which occasionally attain high velocities, but the damage to crops from this cause is not great, as in some parts of the West.

Normal monthly and annual temperature and precipitation.

Month.	Churchs Ferry.		Dunseith.		Month.	Churchs Ferry.		Dunseith.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	°F.	*Inches.*		°F.	*Inches.*	°F.	*Inches.*
January	2	0.63	5	0.10	August	65	1.84	64	1.85
February	3	.51	1	.30	September	55	1.40	.....	.....
March	16	.96	14	.65	October	41	1.71	.....	.....
April	40	2.38	40	1.00	November	17	.87	25	.40
May	53	2.02	54	.90	December	9	.50	8	.10
June	63	3.98	64	3.58	Year	36	19.20	.....	.....
July	68	2.40	68	2.51					

PHYSIOGRAPHY AND GEOLOGY.

In surface features the Cando area is an undulating, treeless prairie, a little rougher near the borders than in the central—particularly the east-central—part. The area is also slightly trough-shaped, with the lowest portion forming a broad, shallow valley that crosses the survey a few miles east of the center. The elevation varies from about 1,475 feet to nearly 1,600 feet, and the general slope is southward. The topography consists of low elevations, the great majority of which have a general northerly and southerly trend. All of the elevations have gentle, gracefully rounded slopes. The topography, however, is not of the dissected type, and bears scarcely any relation to stream-erosion forms, but has been produced by entirely different factors, to be discussed a little further on. Three miles north of Cando, and in a few other places, the surface is made up of knolls and kettlelike depressions, some of which contain small lakes.

The drainage system of the region is unique in several respects. The rather extensive system of streams and drainage lines has not

been developed by the present rainfall, and consequently they are not actively eroding their channels. Many of the streams, or coulées, as they are called in this section of the country, are quite large, and their meandering course indicates that at the time they were developed the fall was not great and the water moved rather slowly. The main stream is the Big Coulée, which crosses the area a few miles east of Cando. With the exception of a small extent of country in the extreme southwestern part, the drainage of which flows into the Hurricane Lake system, the drainage water of the area finds its way into the Big Coulée, either in the county or at some distance to the southward. All of the channels are much clogged by a growth of water-loving plants. At intervals many of the streams pass through broad swales or swampy depressions, from an acre or two to many acres in area, over which the water spreads, while throughout the extent of the survey are numerous shallow depressions of about the same size with no outlets that contain from a few inches to a foot or two of water during most of the year. In the eastern half of the area, aside from the southeastern corner, many of these swamps have the appearance of having been part of a main line of drainage, and are traversed by a distinct channel. In addition, along all of the coulées are many abandoned channels of ox-bow form that have been sufficiently filled to make cultivation possible. The most notable examples of this occur along the Big Coulée northeast of Cando. The former meandering of this stream over a wide territory is here very evident.

In the course of the survey it seemed advisable to indicate on the map numerous lines along which the drainage water collects, and along which, at some earlier time, it was probably drained, and this has been done by means of broken lines. At present these are indicated by poorly drained areas of soil, with discontinuous wet-weather swamps, too small to be shown in the usual way, yet having considerable influence on the agricultural value of the land they traverse.

A further peculiarity is the way in which the various coulées are connected by these lines of drainage, and also the parallel position and near approach of several of the systems to each other. A study of the accompanying map will show two large coulées coming down from the north, one on each side of the Big Coulée, which they gradually approach and into which they finally empty. These, in turn, are formed by the union of streams, which continue parallel and near to each other for distances of several miles.

The surface geology of the area and of all the surrounding country is of the glacial type. The Dakota lobe of the ice pushed down over this country, forming a continuous mantle of glacial till, and during its recession and temporary advances formed lines of gravelly hills called terminal moraines. Associated with these is the roughest topography of the area, in which are found the small glacial lakes.

The melting of the ice during the period of recession produced large volumes of water that drained off to the south, and it was this water, derived from the glacier in the immediate vicinity and from regions many miles to the north, beyond the Turtle Mountains, that produced the system of coulées mentioned above. In The Story of the Prairies, Professor Willard describes the Big Coulée as forming an outlet from large bodies of glacial water far to the northward into Devils Lake and thence into the Red River Valley. The passage of this large volume of water through the area, as floods laden with sediment, and with varying currents, is responsible for the deposit of the large masses of material giving rise to the soils of the area, other than those formed directly from the bowlder clay. The various grades of sand and gravel, mostly stratified in the form of bars and ridges, and of the large mass of silty clay in the vicinity of Cando, were probably formed by this agency of the glacial waters. All of the surface forms are the result, directly or indirectly, of the action of ice, and the depth of the glacial material ranges in different parts of the area from 30 or 40 feet to more than 100 feet.

SOILS.

The most prominent characteristic of the soils in this area is the large amounts of organic matter and lime they contain, as compared with soils of similar texture farther east and south.

The preponderance of organic matter is not due to a larger original amount produced in the soil, but, as was intimated in the discussion of climate, it is a result of the meteorological conditions. The source of all the humus is the plant roots and stems that were left in the soil from season to season by the prairie grass before cultivation began and by the cultivated crops now. All processes of decomposition are hastened by a high temperature, and the longer it continues the more thorough they will be. In this region the summers are comparatively short, the atmospheric temperature is not high on the average, and the soil temperature is comparatively low. This condition hinders the bacterial and fungus growths that are essential to rapid decomposition of organic matter, and a gradual accumulation of humus is the result.

The amount of humus present is the cause of the dark color of the soils of the area—a color that tends to increase the amount of heat absorbed during sunshine, thus maintaining a higher soil temperature. This is an important factor when associated with areas having as short growing seasons as here, and it is probable that the crop adaptation of the region would be quite different if the soils were a very light color, even though they contained the same amount of plant food as at present.

A large amount of lime is distributed through all the types of soil, but is most abundant in the loams and gravelly loams. It has been derived from the grinding up by the glacier of lime-bearing crystalline rocks and also of considerable amounts of limestone. This has been subsequently redistributed and in some places concentrated through the agency of the soil water. The largest accumulations are between the twelfth and the thirtieth inches, where lime sometimes appears to form more than a third of the bulk of the soil. In gravel beds covered to a depth of from 15 to 30 inches by silty material all of the pebbles in the upper part of the gravel are covered with lime, or the whole mass may be cemented together by depositions from the water leached from the soil above.

This large amount of lime is very useful in the soil, since it tends to increase the granulation of the fine-textured types, prevents acidity from the decomposition of the organic matter, which process it hastens, and is favorable to the growth of the grains most abundantly produced in the region. For the growth of flax, however, less lime is desirable.

Five types of soil have been recognized, the names and extent of which follow:

Areas of different soils.

Soil.	Acres.	Per cent.
Marshall loam	79,936	44.2
Clyde loam	70,016	38.7
Clyde clay	18,880	10.4
Clyde fine sandy loam	10,880	6.0
Marshall gravel	1,344	.7
Total	181,056	

All of the types appear very silty in the field, and, except on the lightest sand and gravel points, which are very small in extent, there is considerable similarity in the first 10 inches of soil throughout the area.

CLYDE LOAM.

The soil of the Clyde loam is a black silt loam or loam, with an average depth of 12 inches, but with a range of from 10 to 24 inches. The greater depth is found in the lowest positions adjacent to the coulées. The subsoil is a light-colored silty clay loam, or clay, the upper part, when dry, being a pale yellow to gray, and the color changing to a darker yellow with increased depth. The type has little material coarser than the finer grades of sand.

The Clyde loam is distributed throughout the area, but the largest body is in the eastern half, where it is the predominating type, and

occupies a sort of broad, flat basin, about 10 miles in width, cut at intervals by areas of other types. Toward the eastern boundary of the area and throughout the western half it is the type of second importance in extent, in the latter location forming elongated bodies of variable size surrounded by the Marshall loam.

The surface in general is nearly level or only slightly undulating, while in detail it is appreciably uneven in a number of places, due to shallow channels and saucer-shaped depressions. The large area first mentioned lies at an elevation halfway between the highest knolls and the lowest depression, and in other parts it fills many of the troughs in the surface of the Marshall loam. The shallow depressions mentioned are rather numerous throughout the type, but most of them are of very small extent—less than 2 acres. Where they are of considerable size they have been mapped as a distinct type, because the drainage conditions are such that the soil has been much modified.

The natural drainage of the type is not perfect, and in a region of greater rainfall the condition would be serious; but with the usually light precipitation of this section little trouble is experienced from excess of water, and then only in the wettest seasons and over a comparatively small proportion of the type. Most of the coulées are bordered by the Clyde loam, and it surrounds most of the swampy areas mapped as Clyde clay. Near these in wet seasons the crops may be damaged. In addition, there are lines along which, when there is an excess of moisture, the water tends to accumulate, forming a series of wet-weather ponds a few rods in extent. The most prominent of these lines of drainage have been indicated on the map by broken blue lines. In average seasons all such places may be readily cultivated, and give the largest yields, although there is loss of crops in a wet season. Much of such land could be drained by constructing open or tile drains emptying into the adjacent coulées. Remote from outlets, however, it would not be practicable to put in a drainage system for small areas that are injured only about every fourth season.

Some minor variations from the typical soil material, and other peculiarities in texture that are best described at this point, are: The more coarse and mealy character of the soil in the immediate vicinity north and east of Cando; the noticeably fine sand content of the soil for some distance out from the borders of the bodies of the Clyde fine sandy loam, especially north and east of Cando; the heavier and somewhat clayey subsoil in the lowest places where the drainage is defective, and the slightly heavier character of the type, as compared with the large eastern area, in the small bodies surrounded by the Marshall loam.

The origin of the Clyde loam is not well understood, but it is

thought to be the result of the accumulation of material in the lower levels by the drainage water. Since the volume of this drainage is insignificant at present, the material must have been deposited at some earlier time, presumably during the period when the drainage of the retreating glacier passed through the area. In the vicinity of Cando the depth of this material is 10 feet or more. The character of the surface and the relation of the material to the coulées, as well as to the numerous abandoned channels, which are very prominent along the Big Coulée, northeast of Cando, would seem to indicate the deposition of the material by shallow, slow-moving flood waters. There is no important variation between the material forming the type on the highest levels and that on the coulée bank. The soil is usually a little deeper next to the coulée, but the subsoil is of the same light-colored, clayey character. An example of this occurs along the coulée northeast of Maza, through several sections, and includes several hundred acres, where the black soil is several feet deep next to the channel, and gradually shallows toward the highest level.

The type may be regarded as a secondary material derived originally from the glacial till, but that it is distinct from the bowlder clay is evident.

A large quantity of lime is distributed throughout this soil and is often apparent from the color of the material. The accumulation is largest in the upper part of the subsoil. There is also present a large amount of gypsum ($CaSO_4$), mostly in a crystalline form. It occurs as a granular material in small pockets and seams through the section of the subsoil.

In general, the alkali salts are not sufficiently abundant to be injurious to crops, but there is a slight excess in some instances that is more fully treated under "alkali soils." It is found in the lowest places, where the drainage is most defective, and is most concentrated in the lower part of the soil section.

All the crops of the region, including wheat, barley, oats, flax, and potatoes, are grown on the Clyde loam with good results. In its natural condition it has the highest productive power of any of the soils. In the best seasons wheat will yield from 30 to 35 bushels, barley 40 to 50 bushels, oats 45 to 60 bushels, and flax from 18 to 23 bushels per acre. Not enough corn is grown to determine what the yield would be. Potatoes make 200 bushels or more. These yields represent the maximum returns in favorable seasons, and are the only true guide to the productive power of the soil. In other seasons a great variety of yields is obtained, depending on the amount of rainfall and the management of the land. It is in fact the best soil in the area for the staple crops of the region, and is also well adapted

to the production of potatoes. The same soil farther south would be an ideal one for corn growing. In this latitude, however, a lighter type of soil is better suited to corn. A variety of forage crops and grasses suited to the climate may also be grown successfully. The smooth brome grass thrives on this type. In the best-drained positions potatoes may be made to yield very well, the tubers being of the finest kind. A variety of garden vegetables is also grown, and some excellent small fruits, such as currants and gooseberries, are produced.

In its relation to moisture the type is very satisfactory. It is readily cultivated into a friable loam that takes up water quickly and conducts it into the subsoil, which has a large water-holding capacity. With proper cultivation to conserve moisture, the most protracted droughts of the region may be withstood and fair crops obtained.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clyde loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11646	SE. ¼ sec. 17, Maza Tp.	Black loam, 0 to 12 inches.	1.0	4.9	3.9	15.7	15.8	42.4	16.2
11644	Cen. sec. 26, E. half Badger Tp.	Black silty loam, 0 to 12 inches.	.5	1.1	1.5	9.9	11.2	55.7	19.5
11648	SE. ¼ sec. 20, W. half Badger Tp.	Dark loam, 0 to 12 inches.	.8	2.6	3.0	8.8	11.0	48.9	24.6
11649	Subsoil of 11648	Clay loam, 12 to 36 inches.	1.6	5.3	4.1	10.1	9.8	34.8	34.1
11645	Subsoil of 11644	Clay, 12 to 36 inches	.0	.3	.5	5.2	4.8	47.6	41.5
11647	Subsoil of 11646	Clay, 12 to 36 inches	1.4	3.3	2.1	4.3	5.7	38.2	45.0

The following samples contain more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 11645, 17.8 per cent; No. 11646, 3.2 per cent; No. 11647, 17.4 per cent; No. 11649, 13.8 per cent.

MARSHALL LOAM.

The soil of the Marshall loam is a loam or heavy sandy loam of very dark or black color, containing a small percentage of fine gravel. It is not a very uniform soil, and there are many small, low knolls, from a few feet to several rods in extent, where the material is very gravelly, while in intervening areas the texture is more silty. At from 1 to 2 feet below the surface there generally, but not always, occurs a thin stratum a few inches thick consisting largely of coarse

sand and gravel, while from 12 to 20 inches the material is of a light, often gray color, which is due chiefly to the presence of a large amount of lime carbonate, in extreme instances forming from a third to a half of the bulk of the soil.

The subsoil below the gravelly stratum is a stiff, gritty material, sticky and pasty when wet. The color is a light gray, which changes to a yellow with increased depth. The angular fragments of sand and fine gravel may make up a considerable part of the mass and are mixed uniformly through it. When this gritty material becomes dry it bakes and becomes very hard and resistant.

The Marshall loam is the predominating type of soil in the western as the Clyde loam is in the eastern half of the area. Its surface is very gently rolling or undulating, but not to an extent to interfere with cultivation. The surface is made up of low, rounded knolls and ridges, a large majority of which have a northerly and southerly trend. On some of the higher points are found small beds of gravel that would be classed with the Marshall gravel if they were of sufficient extent. In sections 7 and 18 of Maza Township, on top of a high ridge at that point, these gravel and sand pockets are rather numerous, and associated with them are many large bowlders. These bowlders range from a few inches to several feet in diameter, and bowlders of the same general character are of common occurrence throughout the type. They are angular and subangular in shape, and composed of a variety of minerals. Various kinds of granites are common.

Kettle holes are of frequent occurrence. Many of the depressions between the ridges and knolls are poorly drained and often swampy. This gives rise to the many areas of the Clyde clay associated with this type, which will be noticed on the map, particularly on the eastern margin and in the west-central part. Their presence is a considerable hindrance to cultivation in some places, because they cut the surface into irregular areas.

With the exception of the lowest parts of the depressions between the ridges the drainage is good, and even in the areas excepted, if they are of considerable extent they are shown as a different type. The Marshall loam, as a rule, forms the most elevated part of the area and has a moderately sloping surface and the excess of water readily drains away, while the soil itself being of a porous character, the water that falls upon it is rapidly absorbed. The subsoil, however, is more dense and impervious and absorbs water slowly. The 20 inches or more of porous material on the top has a decided power to retain moisture, and keeping it in contact with the subsoil for long periods the latter gradually becomes moistened. Thus a large amount of moisture may be stored and, by proper cultivation, retained until

such time as it is needed. Some of the wet areas may be easily and cheaply drained, while for others the process would be too expensive to be practicable under present conditions.

The Marshall loam is formed by the weathering of the true bowlder clay which comes to the surface in the areas indicated by the occurrence of the type. With this weathered material have been incorporated considerable quantities of organic matter, but at a considerable depth the blue bowlder clay is found in its original condition, the difference in color being due, it is believed, to the change in form of the compounds of iron, due to weathering.

This type contains more lime than any of the others, but a comparatively small amount of gypsum, and that in the most silty areas. The lime is most concentrated between the twelfth and the twenty-fourth inches, where it may constitute the greater part of the soil mass. The included pebbles are usually heavily coated with it. The small depressions mentioned are often encircled above the line of saturation by a band several feet in width, in which there is a large accumulation of lime at the surface. On these places flax is invariably a failure, and other crops may be affected.

All of the staple crops of the region are produced on this type, but are less uniform in growth than on the Clyde loam. The crops are best in the wet seasons, but even then a slightly spotted appearance in the fields may be observed. In a dry season this lack of uniform growth is much more noticeable. The coarse stratum, being unequally distributed, checks the proper movement of moisture upward to the plant roots, especially when the upper part of the section has become very dry. The process of movement from one part to the other is very slow, and if the upper soil be quickly dried out the plant will suffer for moisture before the supply is replenished from the lower subsoil. There is, in addition, probably a hindrance to the downward development of the plant roots. With the best management the yields of the grain crops may be made to approach very near to those given for the Clyde loam. Flax, however, does not do quite so well.

The following table gives the mechanical analyses of typical samples of the soil and subsoil of the Marshall loam:

Mechanical analyses of Marshall loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11642	SW. ¼ sec. 16, W. half Badger Tp.	Gravelly loam, 0 to 12 inches.	1.2	4.9	3.2	13.8	18.0	42.4	16.6
11638	NW. ¼ sec. 7, Athens Tp.	Gravelly sandy loam, 0 to 20 inches.	7.6	17.9	15.5	15.6	4.6	16.1	22.5
11640	NW. ¼ sec. 17, Coolin Tp.	Black loam, 0 to 18 inches.	3.0	4.7	5.7	18.7	17.4	24.1	25.9
11639	Subsoil of 11638	Sandy clay, 20 to 36 inches	9.2	23.4	15.3	15.0	3.8	11.2	21.8
11641	Subsoil of 11640	Sandy-clay loam, 18 to 36 inches.	2.0	6.2	3.7	13.9	17.0	25.2	31.2
11643	Subsoil of 11642	Light-colored clay, 12 to 36 inches.	2.2	5.2	3.4	10.8	10.0	28.6	39.3

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11638, 11.3 per cent; No. 11639, 20 per cent; No. 11640, 8 per cent; No. 11641, 25.3 per cent; No. 11643, 17.3 per cent.

CLYDE FINE SANDY LOAM.

The Clyde fine sandy loam consists of a very dark or black fine sandy loam, 12 inches in depth, beneath which is a pale-yellow or gray fine sandy loam or fine sand that extends to a depth of from 2½ to many feet. The sand subsoil is found in areas occurring on the highest knolls. This is the case on the highest elevations in section 1 and the northeast quarter of section 8 in the eastern half of Badger Township; and through the center of section 19, in Maza Township, the subsoil is in part a very clean sand, near the medium in grade.

This type is confined almost entirely to the eastern half of the area, where it forms several bodies of more than a square mile in extent. It is closely associated with the Clyde loam and Marshall gravel, and occurs most commonly in small bodies surrounded by the former type and around the base of the latter as a gradation type.

The surface of all of the small bodies of the type is in the form of low knolls or ridges with a gently rounded outline. In sections 4, 5, and 6 of Coolin, and section 1 of Maza Township it occupies the intervening depressions as well as the elevations. In the comparatively large areas north and east of Cando it forms hills of considerable height.

Owing to the elevation, the slope of the surface, and the porous character of the material, the drainage is exceptionally good.

The origin of this type, like that of the Clyde loam, is believed to be associated with the post-Glacial drainage of the region. It is frequently underlain by silt, and often occupies such a position with reference to the drainage channels as to suggest its having been deposited in part by the flood waters of an earlier time. It is free from pebbles and Glacial bowlders. It is rich enough in lime to effervesce freely with acid, although the soil particles do not appear to be flocculated to any great extent. No crystals of gypsum were observed in this soil.

All of the staple crops are grown, but the yields are appreciably less than on the Clyde loam, and, as a rule, are less than on the Marshall loam. In some instances, where the sand formation is not over 3 feet in depth and grades into silt, the crops are as good in a moist year as on either of the other types. But the moisture-holding power as a general thing is less and the soil is more affected by dry weather. On the average, wheat will yield from 20 to 25 bushels in the most favorable seasons, and other crops proportionately. Some uniformly good crops of flax were observed on this type, but the yield of seed is not so large as on some of the types already described. For the production of corn, potatoes, and garden vegetables it is the best type in the area, because it is a warmer soil, but it can never be made to produce yields of the small grains equal to those of the heavier types. One essential condition to the production of corn and the other crops enumerated is frequent cultivation to conserve moisture.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clyde fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11636	NE. ¼ sec. 6, Coolin Tp.	Fine sandy loam, 0 to 15 inches.	0.3	1.4	4.3	36.4	28.1	18.8	10.5
11634	Cen. S. line sec. 2, E. half Badger Tp.	Fine sandy loam, 0 to 12 inches.	.2	2.9	5.6	34.2	25.6	19.8	11.5
11637	Subsoil of 11636	Fine sandy loam, 15 to 36 inches.	.2	1.0	3.2	35.5	35.7	10.0	14.4
11635	Subsoil of 11634	Fine sandy loam, 12 to 36 inches.	.6	4.7	7.7	34.8	22.9	12.8	16.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11635, 9.4 per cent; No. 11637, 5.3 per cent.

MARSHALL GRAVEL.

The soil of the Marshall gravel is a dark-brown or black sandy loam, 8 or 10 inches in depth, and containing a considerable proportion of coarse sand and fine gravel. The subsoil consists of loose coarse sand and gravel, much cross-bedded and several feet in depth.

The type is of small extent, occupying not more than 2 square miles. It forms narrow, elevated bodies at widely separated points. Two of these are in the southeastern and southwestern quarters of the area, respectively, and a third and the largest is on the northern margin north of Cando.

The Marshall gravel occurs as isolated knolls and ridges, and is found capping the highest elevations in the area. The largest area forms a large hill, the general surface of which is rolling.

The origin of the type is in some way associated with the glacial drainage of the region. The gravel is very angular, and some of the strata consist of nearly pure quartz sand, while others are made up largely of shale fragments, including an occasional large bowlder. In the upper part of the beds, immediately beneath the sandy soil, the rock fragments are heavily coated with lime.

The surface soil is too shallow and the soil as a whole too droughty for successful crop production, and although most of it is in cultivation to the small grains, the yields are small, in dry seasons scarcely any grain being obtained.

CLYDE CLAY.

The Clyde clay, from 8 inches to 2 or 3 feet in depth, is a black clayey loam, very rich in organic matter, with surface accumulations of a few inches of muck in some places. Beneath the dark soil is a very light-colored, often nearly white, material that varies from a heavy pasty clay to a heavy silty clay, in some instances mixed with sand and gravel, although the last is of infrequent occurrence. The subsoil usually found is a rather heavy clay that becomes more silty at a depth of 3 or 4 feet. In some instances the clay is underlain with sand. Where the heavy clay approaches to within 3 or 4 inches of the surface, so that it interferes with cultivation, it is called "gumbo."

The Clyde clay is scattered through the area in bodies from a few rods up to several hundred acres in extent. It is associated with all of the other types and occupies the lowest levels. It occurs along coulées, in abandoned stream courses, in depressions at higher elevations, and in all other places where the natural drainage is very defective.

The type owes its origin to its low, flat surface, which is often dish-shaped, and the consequent poor drainage. It represents areas where

the surface water accumulates and where the small amount of fine material carried in suspension has been deposited from year to year to form the fine clay. In this material, which is covered by water to a depth of several inches during much of an average season, many water-loving plants—mostly grasses—grow in great luxuriance, their decaying roots and stems accumulating from year to year and with the annual addition of sediment forming the rich black clay loam that covers the bottom of such places.

Most of the type is a virtual swamp during the early part of the season, and in wet years is covered with water through the whole summer. On the map this part of the type is designated by swamp symbols. Other parts that have been formed in the same way, but over which better drainage has been established, are under cultivation. The largest of these are in the center of Maza Township, and adjoining the Big Coulée in the southwest corner of Coolin Township. The soil of these areas is a heavy black clay, to which the name "gumbo" is frequently applied. A large part of this type may be cheaply drained, but there remain other considerable bodies over which it would be very difficult and expensive to establish drainage, because of the lack of a ready outlet.

Most of the alkali in the area is found in this type. The salts are apparently accumulated in these places through the agency of the drainage waters, and subsequently concentrated by evaporation, which in some seasons is relatively great. Heavy crusts of salt often form on the borders of the saturated soil, and over small areas all vegetation is killed. The water in such depressions is often brackish, and in some places more so than in others. The problem of drainage and cultivation for the correction of alkali soil is discussed under "alkali soils."

Those areas of the Clyde clay with a fair drainage are devoted to the production of grain, and in seasons of moderate rainfall very large yields are obtained. In very wet seasons, like the present one (1904), the crops over a great part of the area are ruined by the excess of water. If properly drained and well cultivated this type will produce larger yields of wheat than any of the other types in the area. Most of the type is at present used for the production of natural grasses, which in the average season furnish nearly all the hay used in the area. If the areas do not become dry the hay can not be cut, as was the case in the season of 1904, but even in this case a large quantity of hay is obtained around the edges of the areas, where in other seasons scarcely anything would be harvested. The fact that so much and so good hay is obtained from these wet places inclines the farmer to retain them in their present condition rather than to put them under cultivation, especially as this would generally entail considerable expense for drainage.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clyde clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11652	SW. ¼ sec. 23, E. half Badger Tp.	Loam to clay, 0 to 12 inches.	0.0	0.7	0.8	6.3	14.7	43.7	33.7
11654	SE. ¼ sec. 20, W. half Badger Tp.	Black clay loam, 0 to 20 inches.	Tr.	1.4	1.4	6.8	7.1	45.6	37.7
11650	SE. ¼ sec. 16, Maza Tp.	Black clay, 0 to 12 inches.	.4	1.0	1.0	5.3	5.6	42.4	44.3
11653	Subsoil of 11652	Clay and silty clay, 12 to 36 inches.	.0	.2	.3	5.9	24.4	32.2	36.9
11655	Subsoil of 11654	Heavy clay, 20 to 36 inches.	Tr.	.8	1.0	4.0	6.8	48.3	39.1
11651	Subsoil of 11650	Dark stiff clay, 12 to 36 inches.	.0	.8	.8	3.2	4.1	32.0	59.1

The following samples contain more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 11651, 7.4 per cent; No. 11652, 1.1 per cent; No. 11653, 3.4 per cent; No. 11654, 1.9 per cent; No. 11655, 1.9 per cent.

ALKALI SOILS.

Except in a few instances, the condition of the soils of the area as regards excess of injurious salts is not serious, and under proper methods of soil management will never affect seriously the productiveness of the soils in this part of the State.

While there is a considerable quantity of alkali through the glacial mantle, and while in a truly arid climate and with careless irrigation the conditions are such as would give cause for alarm, the rainfall is sufficient to prevent any marked accumulation of the salts within the root zone of the soil over by far the greater part of the area, and what accumulation has taken place is confined mainly to localized spots in small depressions, or in somewhat larger areas of poor drainage. The salts found in such places have been leached from the soil of higher lying areas by the rain water, and have been retained there through obstructed drainage.

A few places were observed on the uplands in the vicinity of some of the larger moraines where the alkali was gradually being leached out of the glacial material and brought to the surface lower down, on the gentler portion of the slope, but the most important occurrences of the alkali salts are confined to the poorly drained areas along the sloughs and coulées and in the vicinity of the lakelets. Among the more important occurrences may be mentioned the lowlands along

the Big Coulée and its larger tributaries, a small, irregular area west and northwest of Maza, a tract around Hurricane Lake, and a small area about 4½ miles north of Cando. Other small areas are found in various parts of the eastern half of the survey. As already stated, the alkali in this area nearly always occurs in small spots and patches, which usually mark places of obstructed drainage.

The alkali in this area owes its origin to the grinding down by glacial action of the various silicate rocks that lay in the path of the ice sheet. Innumerable rock fragments are found scattered all over the country, and range in size from small pebbles to bowlders weighing many tons. Rocks containing the lime, soda, and potash feldspars predominate, while scattered here and there are found many of the more basic igneous rocks, such as diorites, diabases, gabbros, and various members of the peridotite group. It is doubtless true that from the comminution of these basic igneous extensions much of the sulphur, relatively so abundant in the soil in the form of sulphates, is derived.

Most of the salts in the Cando area are in the form of sulphates. Samples from the worst alkali spots when analyzed by the Bureau of Soils showed that no sodium carbonate was found; neither was any detected by titrations made in the field. The sulphates of calcium, potassium, sodium, magnesium, and the bicarbonates of the last three constitute the principal salts. Some sodium chloride, or common salt, is present, but none of the analyses showed as much as 2½ per cent of the total salt to be sodium chloride, while there was often 85 per cent of the sulphates. Most of these salts are soluble in water, the principal exception being that of calcium sulphate, or gypsum, which is relatively insoluble.

While the soluble salts of this area are distributed throughout the whole mass of the soil, it is interesting to note the total absence of harmful amounts of alkali in the surface of nearly all the well-drained upland soils. This is especially true in the case of the Marshall loam. The Clyde loam usually contains more salt than any other type in the area, except the clay loam along the coulées and sloughs. In all the well-drained areas, where the alkali is at all noticeable the amount always increases with depth. Cultivation, cropping, and surface leaching have removed the excess from the surface few inches. Excessive accumulation has been largely kept in check by the nature of the crops grown—crops that tend to allow the least possible amount of evaporation during the growing season; by the large amount of humus in the soil, which creates humic acids that tend to neutralize the alkalinity of the soil; by summer fallowing, which inverts the soil and places next to the subsoil any excess of salts that may have accumulated on the surface, and by the spasmodic nature of the rainfall, which occasionally comes as cloudbursts and

flushes from the surface the alkalies that have been deposited by evaporation.

Near the coulées and sloughs and in all the poorly drained areas in the survey the distribution of the alkali in the soil is different from its distribution on the higher levels. Here evaporation causes the salts to accumulate on the surface, and many places are seen in these lowlands where plants are either dead or dying.

The accompanying table shows the amount of salt to increase with depth. Borings Nos. 13, 15, and 20 were taken in poorly drained areas where evaporation had deposited considerable salt near the surface.

Table showing distribution of salts in soil as found in Cando area, North Dakota.

No. of boring.	Location.	Foot.					
		First.	Second.	Third.	Fourth.	Fifth.	Sixth.
1	SE. ¼ sec. 36, R. 65 W., Badger Tp	0.05	0.32	0.46	0.495		
5	NW. ¼ sec. 5, R. 65 W., Coolin Tp	.225	.145	.115	.055	0.063	0.083
6	Same as No. 5, but a few feet away	.042	.05				
7	Same as No. 5, but a few rods away	.04	.05	.06			
11	Sec. 16, Maza Tp	.51	.64	.69			
12	NE. ¼ sec. 31, R. 65 W., Badger Tp	.16	.33	.41			
13	NE. ¼ sec. 6, Maza Tp., near coulée	.54	.24	.20			
15	Big salt flat NW. of Maza	.94	.74	.80			
20	SE. ¼ sec. 32, Maza Tp	.47	.24	.23			
22	NW. ¼ sec. 12, R. 65 W., Coolin Tp	Tr.	.44	.44			
24	SW. ¼ sec. 31, R. 65 W., Coolin Tp	.19	.41	.60			

In the more important alkali areas along the sloughs and coulées surface drainage should be resorted to wherever possible. Underdrainage is usually impracticable, and in most cases unnecessary, because the only requisite is that the salts be kept below the zone of root action, and good surface drainage, with deep and thorough cultivation, accomplishes this result, the crops of the area being for the most part shallow rooted.

AGRICULTURAL METHODS.

The region is devoted almost exclusively to grain production, and of the grains spring wheat is far in the lead in acreage and total yield. It is the staple money crop. The other crops grown are barley, oats, flax, emmer (spelt), hay, and a very little corn, and some millet. The wheat, flax, and part of the barley are marketed, and the remainder of the grains and the hay are fed on the farm. The hay is almost all derived from the swampy places mapped as the Clyde clay. A little smooth brome grass is grown, but its introduction was recent, and it is confined to a number of small areas that are chiefly experimental. It appears to be adapted to the soil and climate, and, as it is,

both a good hay and pasture grass, the acreage will undoubtedly be greatly increased. It does best on the Clyde loam, and fairly well on the Marshall loam.

For wheat, and in fact any of the grains, as much of the land as possible is plowed immediately after harvest, as owing to the short season there is none too much time in the spring. The depth is from 5 to 7 inches, except in breaking the prairie sod, when only 2 or 3 inches of the soil is turned. The fall-plowed land is generally left in the rough condition through the winter, but a few farmers harrow down their land as fast as plowed, and repeat the process as often as time will permit. They claim profitable results from the practice. In the spring the plowed land is worked into condition, and as early as the season will permit—in the latter part of April or in May—the seed is sown. The thoroughness with which the seedbed is prepared varies greatly with different farmers and in different seasons, but it is generally known that the more care and time bestowed in this preliminary work the better the crop returns will be, especially if the season be an unfavorable one. Wheat is seeded first, and the other crops in the order of their importance to the particular farmer. Oats, emmer, and flax require a comparatively long season, while barley will mature much more quickly. As a consequence, a greater acreage of barley is sown in wet years, when the season has become late for sowing the other grains. It is often sown in sloughs and wet, cold places in the other grain fields, where it alone will be able to mature.

No well-established rotation is practiced, though many farmers have a succession that they prefer and follow as far as the seasonal conditions will permit. On new land barley or flax is the first crop, following which wheat is grown for two or three years. Barley or flax may follow, and in turn be succeeded by oats. After oats neither wheat nor barley appears to do very well, and flax gives the best results. Where summer fallowing is practiced it should follow oats.

Summer fallowing is practiced to a considerable extent, the land being plowed late in summer, when most of the weeds are in bloom. The two objects that guide this practice are to permit the land to recuperate and to destroy weeds. For the latter purpose frequent harrowing during the season is essential, and this practice also has the advantage of conserving moisture. It is also recognized that a thoroughly cultivated crop like corn or potatoes gives equally as good or better results in the succeeding grain crop as fallowing.

By the best farmers cultivated, fallowed, and new land is sown in wheat, and after fallowing wheat is sometimes grown for two or three seasons in succession. Oats and barley are largely utilized to free land from weeds by overtopping and smothering them with their leafy growth. Oats and emmer are sometimes sown together for feed.

Emmer yields as much as 75 bushels per acre, but is very light and chaffy, and in yield of grain does not materially exceed some of the other crops like barley. Some macaroni wheat is sown, and this crop is growing in favor. A careful farmer who has had experience with it estimates that in a dry season macaroni wheat will exceed the common wheat in yield by about one-third. In other seasons the yields are about the same.

Wheat and the other grains are cut with binders and thrashed from the shock. The stubble is cut high, and when sufficiently thick is burned, after the shocks have been removed, to kill weeds. Two species of mustard, sunflower, foxtail, and a number of other weeds become very troublesome in the grain fields.

Very little corn is grown, and this is frequently injured by early frost, although in some years mature grain is obtained. The principal use of corn is as fodder, but its harvesting conflicts with that of the small grains, and on the same farm the latter are given the preference. The corn should be planted on the lighter, sandy soils, care being given to maintain the moisture supply by frequent cultivation.

Potatoes are grown, but only for home use. The tubers are large, smooth, and of fine quality. Following potatoes, very large crops of grain are obtained.

Cattle and hog raising is confined to a few farmers. The cattle are of the beef type, except a few that furnish the local dairy supplies. The native prairie is used for pasture, and swamp hay and ground small grains are fed in winter. The great bulk of the feed is consumed at home by the many horses that are necessary in farming operations.

Except on a few of the best-managed farms, the manure from the stables is not applied to the land, though largely increased crop returns are realized from its use.

The moisture conditions determine the crop yields in this region, and those practices that concentrate the most moisture within reach of the plant roots give the best results. It is best to plan the management of the land with reference to dry seasons, since they are of more frequent occurrence, and in the wet years the same practices will give good results, though not much larger yields than result from less thorough methods under the prevailing conditions. Plowing to a depth of from 6 to 8 inches provides a larger reservoir for moisture storage than shallower plowing and gives a larger space through which the plant roots may readily distribute themselves. The under part of the furrow slice should be well packed down, so that it will be in close contact with the unturned soil, which process aids in the distribution of water downward in times of rain, hastens the decay of organic matter, and permits the plant roots to extend below the depth of plowing. The deeper the rooting the better can

protracted drought be withstood. It should be the aim to get into the soil all of the water that falls and to retain it there until it can be taken up by the plants. To retain moisture the surface should not be left hard, rough, or exposed any longer than is absolutely necessary. It is desirable to plow the land or disk the surface to the condition of a mulch as soon as the crop is removed, and if plowed it should be immediately worked down, and the surface kept loose and fine by the use of a shallow harrow. This applies particularly to fallow and fall plowing. It is said by some farmers that a loose, smooth surface in winter permits the fine top soil to blow and the snow to be carried away by the wind. If surface cultivation is practiced as soon as the soil is sufficiently dry not to puddle, the blowing will be prevented. The blowing of the snow does remove some moisture, but while it is melting the surface of the ground is frozen, so that a comparatively small amount enters the soil, and is more than balanced by the amount conserved by summer cultivation. It might be found advisable in some years to roughen up the surface of the ground late in the fall, so that it would hold the snow.

It is recognized that even in dry seasons those crops that are cultivated seldom fail to make a good growth. This is largely because evaporation from the surface is checked by the loose top soil. Spring harrowing of the grains is practiced on at least two farms in the area with good results. The practice may be continued until the plants begin to joint or reach the stage when they completely shade the ground.

All of the above practices for the accumulation and retention of moisture are to be recommended, but it is recognized that it will not always be practicable to apply them completely. Their use must be governed by the question of economy in each case, but it is believed that if more attention be paid to the conservation of moisture considerably increased profits will result on many of the farms of the area.

AGRICULTURAL CONDITIONS.

The farmers of the Cando area are generally in a fairly prosperous condition. The number of really good houses is not large, although many of the farms have large, substantial barns, and within the last three years many fine farm buildings have been erected. On the remaining farms the buildings are the primitive "shacks" of the homesteading settler. Much machinery of modern patterns is used, and the horses and other live stock are of good types. The acreage of improved land is increasing, and the value of farm land has risen rapidly in the last five years. Much of the debt incurred only a few years ago in establishing new farms is being liquidated, and the amount of land offered for sale is constantly decreasing. The value

of land ranges from about $10 an acre for the most remote prairie to $35 or $40 for the cultivated land near the shipping points.

According to the census of 1900, 76 per cent of the farms in Towner County are operated by the owners, and that figure probably represents conditions in the area surveyed. Renting, where practiced, is usually on a basis of a share of the crops, the proportion being one-half of the grains thrashed where the owner of the land furnishes half the seed and pays half of the thrashing bill. At least one large farm is operated by a resident manager.

The average size of farms in the county in 1900 was 289 acres, but the average in the area surveyed will probably exceed that figure considerably. A large number of farms contain from 300 to 500 acres each, several exceed 1,000 acres, three or four exceed 2,500 acres, and one contains 4,300 acres. Land is handled on the basis of the quarter section of 160 acres as a unit, and the price is often quoted by the "quarter."

A large amount of labor is required during part of the year when crops are being seeded and harvested, while at other times only a few men are employed. To meet this irregular demand large numbers of men are imported from other sections of the country. Those employed through the year are engaged by the month at a wage of from $25 to $35. Ordinary day labor is paid from $2 to $3, and where skilled mechanics are employed their wages exceed these figures. Subsistence is also furnished to those employed.

All of the cultural operations are performed on an extensive scale, and each man is expected to handle wide-cutting implements and from 3 to 8 horses. Plowing is done with a double gang plow drawn by 5 or 6 horses. Four horses are used in the ordinary binder, 6 in the rear-draft binders and headers, and 4 in the seeders.

The four grains, wheat, flax, oats, and barley, occupied, in 1900, 99 per cent of the area of all cultivated crops, with relative acreages as follows: Wheat, 62.8; flax, 14.5; oats, 13.9; and barley, 7.9 per cent. Since that date there has probably been a relative decrease in the acreage of flax. Hay is produced from the swamp land and is a natural growth. Thirty-four per cent of the total value of farm products is placed on the market, the remainder being fed to live stock.

Since wheat is the principal product in the area, it is of interest to know the cost of producing a bushel of this grain. On one of the largest farms, where accurate records of operations and expenses had been kept for a series of ten years, the average yield per acre was ascertained to be about 20 bushels, and the cost of production and marketing, aside from a charge for rent on the land, amounted to 41 cents a bushel when 1,000 acres or more were grown, and nearly

47 cents when less than 500 acres were grown. As this farm is probably more carefully managed than the average farm, the cost of production is below and the yield above the average for the area. The soil on this farm is mainly the Clyde loam, with small bodies of Clyde fine sandy loam included.

No attention is paid to the adaptation of soils to crops. Crops are grown wherever the conditions will permit a fair growth to be obtained. The yields are largely influenced by the seasonal moisture conditions, and the same land does not return the same yield year after year. The heavier lowland soil, embraced chiefly in the type Clyde loam, is the most productive for the grains. As a rule, flax succeeds best on the same type of soil, but in some places it is so damaged, it is thought, by the excess of lime in the soil that its growth is uneven.

As the region becomes more intensively cultivated the need of additional crops will be realized. Rape and root crops grow well on the heavier types, and corn and vegetables do best on the heavier parts of the sandy loam. It may be found that leguminous crops and additional grasses can be produced. Some excellent growths of white clover have been observed. These crops will be useful only should the raising of live stock become more important.

The Great Northern Railroad, with the St. John branch line, affords the only facilities for transportation of the products of the area to the markets, which for all of the principal crops are beyond the borders of the State. The county road system is rectangular, with a road legally on each section line, though in reality the roads are not so frequent, because the present population is not sufficiently dense to utilize so complete a system, while on many of the lines there are barriers to travel that can only be removed at large expense. The main roads through the county are improved by grading and bridges, but none of them is surfaced. Most of the heavy hauling of grain and of supplies for remote points is done in the winter when the ground is frozen.

Since the population is essentially an agricultural one, or dependent on agricultural interests, it necessarily follows that the local market for produce is very small. The grain goes east to the mills and to distributing points, and most of the supplies come in from the same source. There are ten elevators at Cando and four at Maza, through which the grain is handled. Most of it is sold directly to the elevator companies, but the farmer may ship his own grain, in which case, at a cost of from 1½ to 2 cents a bushel, the elevator will receive, store to a limit of fifteen days, and place on board cars. Storage charges are 1 cent per bushel per month for short periods and a less rate for a longer time.

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(voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provide
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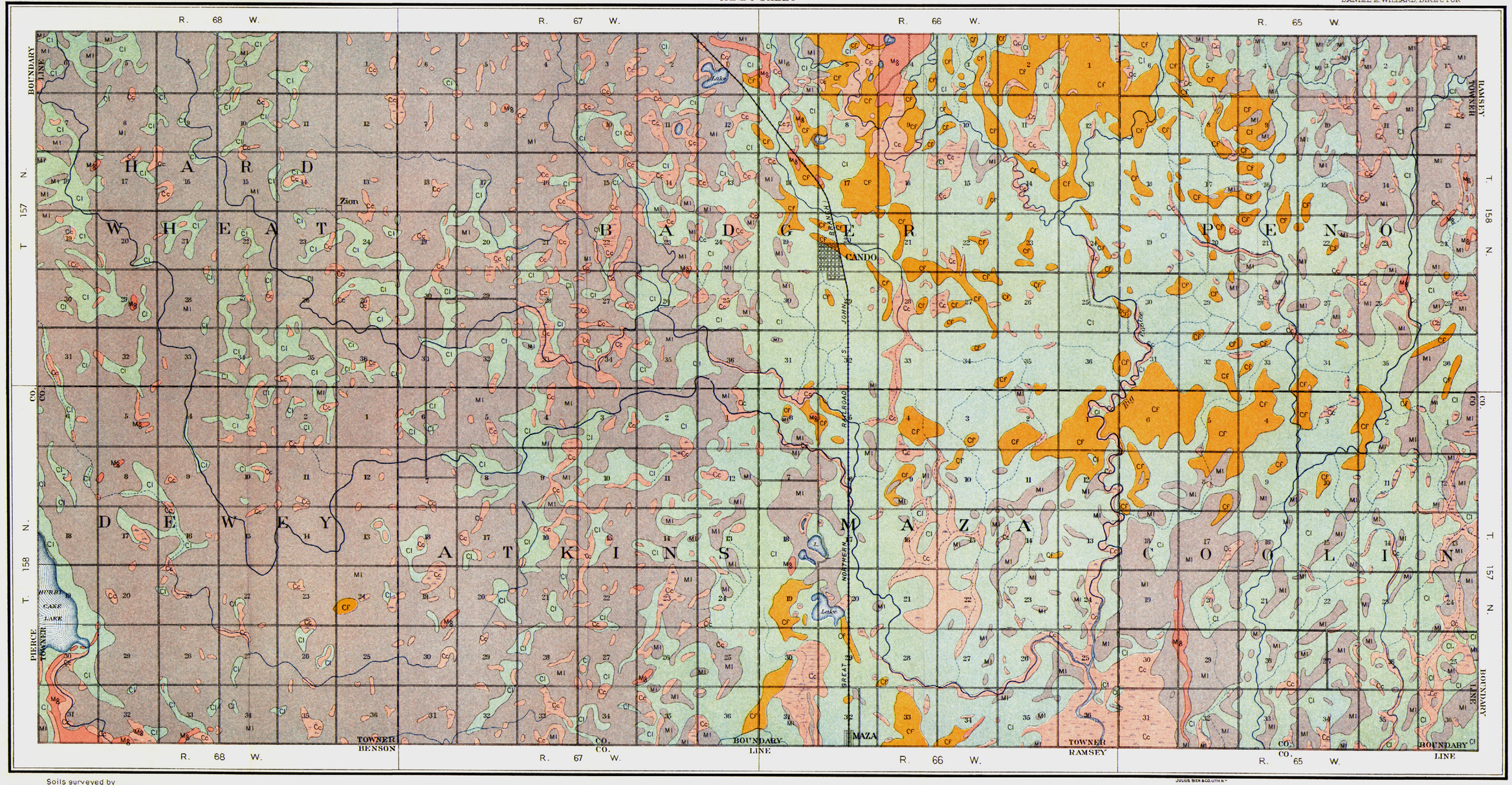
U.S. DEPT OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF

SOIL MAP
NORTH DAKOTA
CANDO SHEET

AGRICULTURAL AND ECONOMIC
GEOLOGICAL SURVEY OF NORTH DAKOTA
DANIEL E. WILLARD, DIRECTOR



SOIL PROFILE
(3 feet deep)

Marshall gravel — Sc, Scc
Clyde fine sandy loam — Sfsc, Sfsc
Marshall loam — Sc, Sc, Scc
Clyde loam — Sc, C
Clyde clay — Scc, C

LEGEND

Sc, Scc — Loam and gravel
Sc, Scc — Sand and gravel
Sfsc — Fine sandy loam
Sc — Loam
Scc — Clay loam
C — Clay

LEGEND

Mg — Marshall gravel
Cf — Clyde fine sandy loam
Ml — Marshall loam
Cl — Clyde loam
Cc — Clyde clay
Swamp

Soils surveyed by
Elmer O. Fippin and James L. Burgess
1904

Scale 1 inch = 1 mile

Field Operations
Bureau of Soils
1904

JULIUS BIEN & CO. LITH. N.Y.